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Evolving techniques for monitoring geotechnical risk on the Antrim Coast Road.

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Using satellite data to remotely monitor deformation of civil engineering infrastructure with millimetre precision.

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Queen's University Belfast together with the British Geological Survey (BGS) and the Geological Survey of Northern Ireland (GSNI) have just embarked on an exciting new research study to illustrate how satellite radar interferometry (InSAR) techniques can be used to remotely assess small ground movements in geotechnical or structural infrastructure, with millimetre precision. The satellite radar data is available from 1992 onwards and can be used to either assess historical ground movements or alternatively monitor current movements or ground subsidence.

The research team at QUB and BGS are working with three major local stakeholders, TransportNI, Northern Ireland Rail, and the Department of Trade and Industry (DETI) and ARUP to help embed InSAR monitoring techniques in their organisation to improve their methods of managing geotechnical risk. The intention is that this project will demonstrate the many benefits of using InSAR, such as coverage of large and remote areas not easily accessible on foot and consistent accuracy of the measurement of small movements over long periods of time.

The project will examine landslide instability and subsidence at 4 major sites. Study site one is in North Belfast along the edge of the basalt escarpment. Historically this area has been subject to shallow translation landslides and evidence of movement can be seen for in Ligoneil Park and along the Antrim Road. The second study site is on the railway line between Belfast and Bangor where sections of the track are in steep sided cuttings prone to instability, particularly after periods of heavy rainfall. The third site is the abandoned salt mine workings around Carrickfergus. These mine workings have caused huge crown holes to appear at various locations around Carrickfergus as a result of mine collapses. This area is currently monitored by DETI using ground based survey techniques. Figure 1 shows a spectacular crown hole which appeared in 2001. The fourth site is at Straidkilly on the Antrim Coast Road. This section of road cuts through soft Jurassic clays and debris from the slide area has frequently spilled onto the road closing it at times (Figure 2).

Put simply InSAR works by scanning the Earth's surface from various satellites using radar frequencies (see Figure 3). The scans are taken at regular intervals and the Earth's motion or deformation can be inferred by the examining the difference between successive scans. Rates of movements of sub millimetres per year can be achieved provided strong radar reflections are achieved from the Earth's surface.

One recent example of the power of this technique is illustrated in Figure 4 which shows the ground subsidence following the excavation of the Jubilee line extension in London between 1992 and 2000. The green dots are radar reflections with zero movement while the yellow and red dots, coincident with the line of the Jubilee tunnel, show surface subsidence of up to 15mm/year (Cigna, F. et al, Journal of Pure and Applied Geophysics, 2015).

Clearly the applications of this technique are many and it may not be too long before we can measure road surface deformation (rutting) or embankment subsidence from these satellite data.

The project is funded by NERC under the Environmental Risks to Infrastructure Innovation Programme. For further details contact David Hughes at Queen's University Belfast d.hughes@qub.ac.uk



Figure 1 Large crown hole above abandoned salt mines near Carrickfergus in 2001



Figure 2 Debris from landslides along the Antrim Coast Road

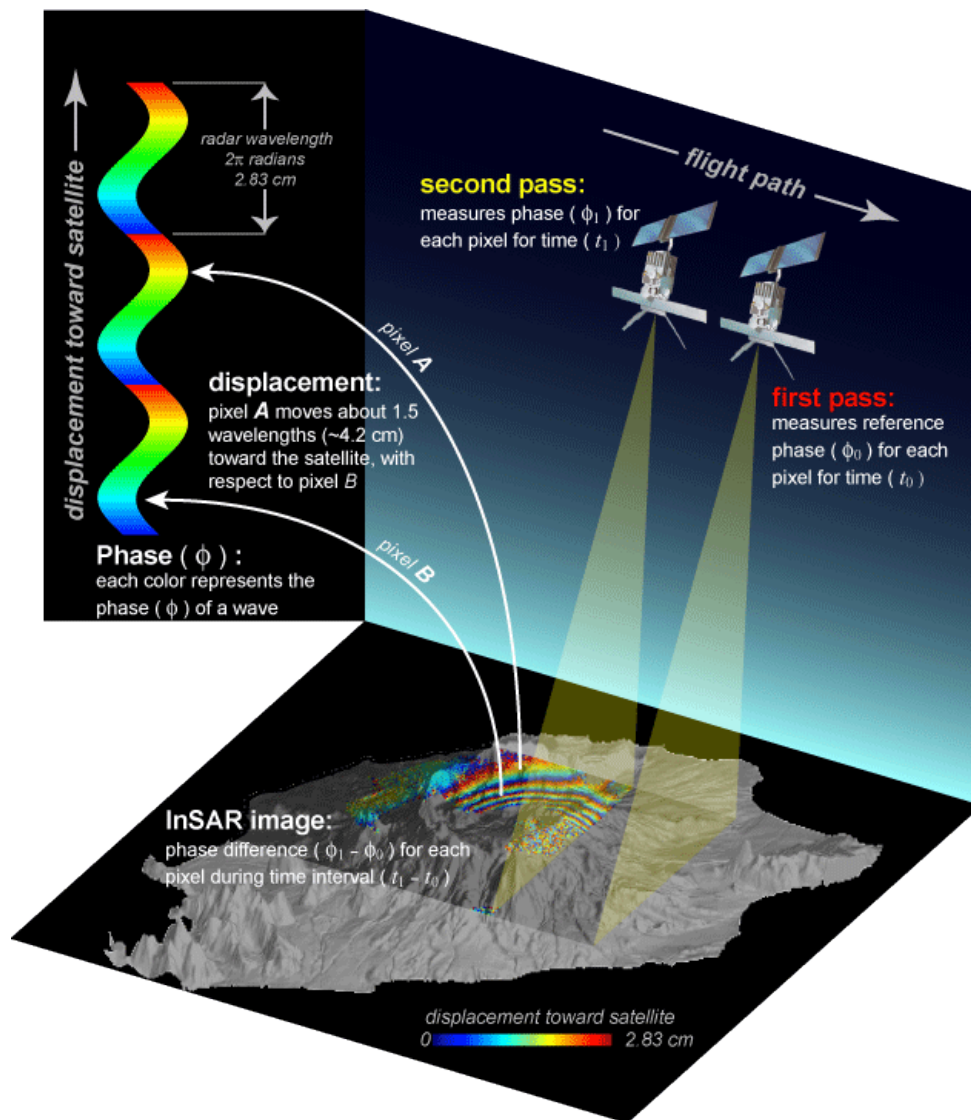


Figure 3 Schematic of the collection and processing of InSAR images (source: http://www.insar.sk/en/insar_technology/)

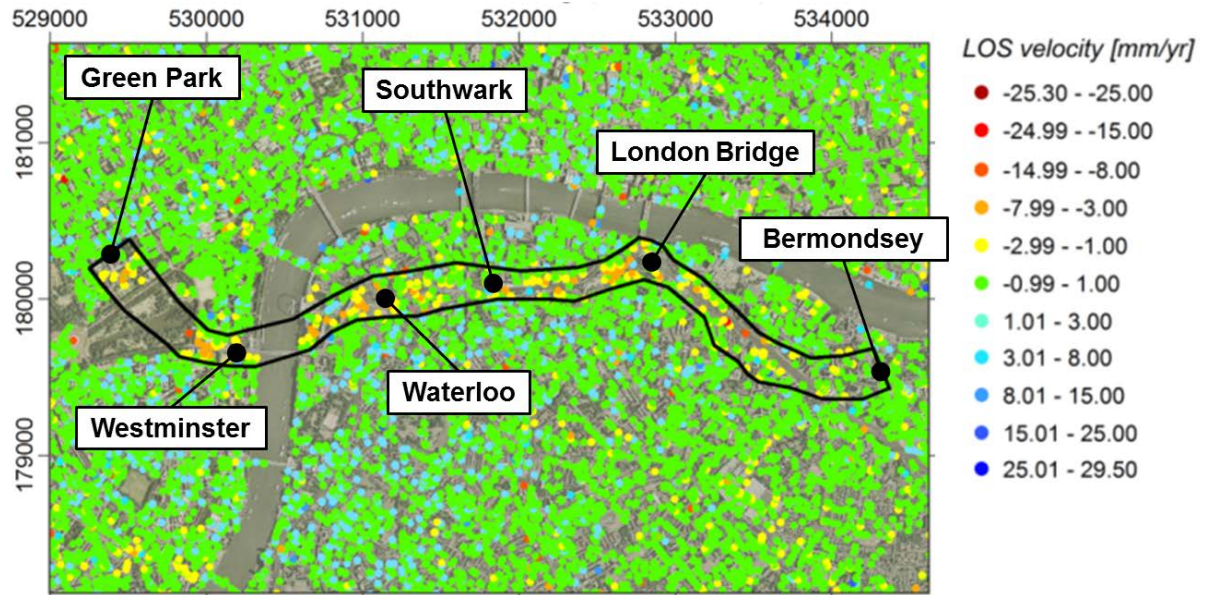


Figure 4 InSAR data showing subsidence along the Jubilee line extension in London in 1992-2000 (Cigna, F. et al., 2015)